

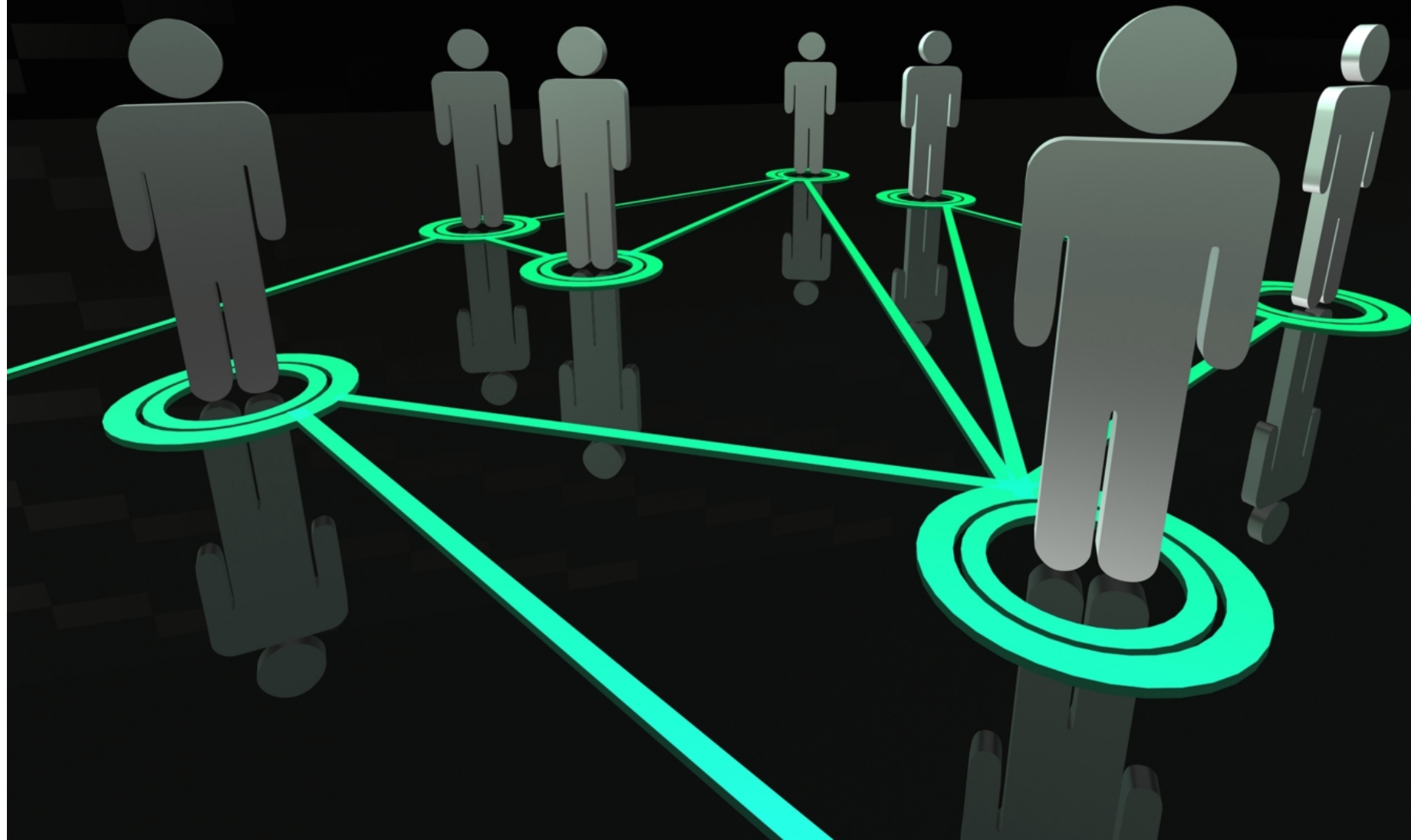
Network Analysis and Cytoscape





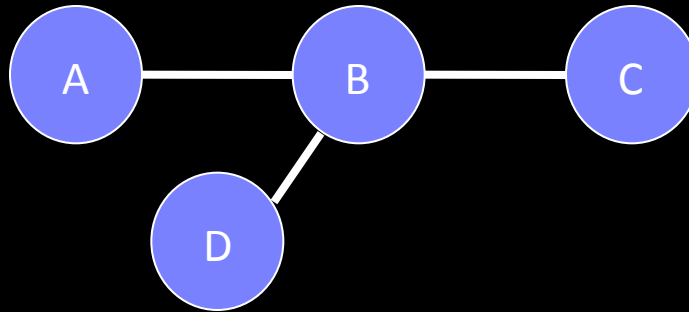
Network modeling and analysis

Social network theory



Graph theory

Nodes and links



Equivalent representation:
Adjacency list

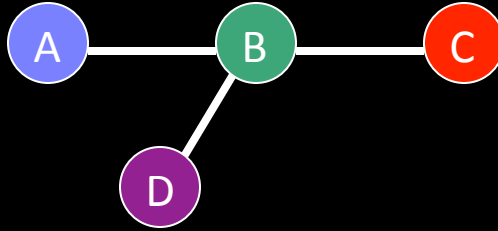
A B

B C

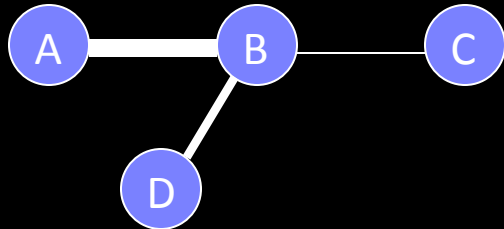
B D

Variations

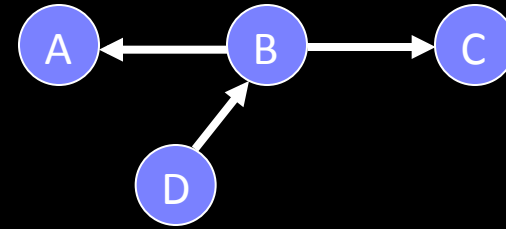
Different types of nodes



Links of varying weights



Links going a particular direction



Examples of networks



- Genetic regulatory networks
- Protein-protein interaction networks
- Biological neuronal networks
- Transportation networks
- Collaboration networks of scientists
- Link structure of the World Wide Web

Source: Watts, D. J. (2004). "The 'new' science of networks." Annual Review of Sociology 30: 243-270.

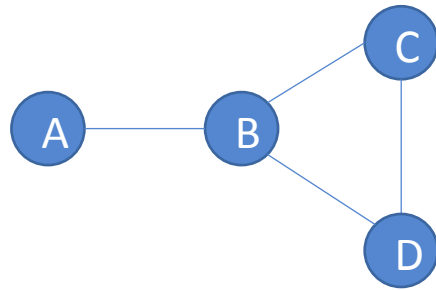
Properties common to many real-world networks

- Short average path length
 - Strong local clustering
- } **Small-world**
- Power-law distribution in links for each node
- } **Scale-free**

Properties common to many real-world networks

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Diameter and path length



Path lengths

$$AB = 1$$

$$AC = 2$$

$$AD = 2$$

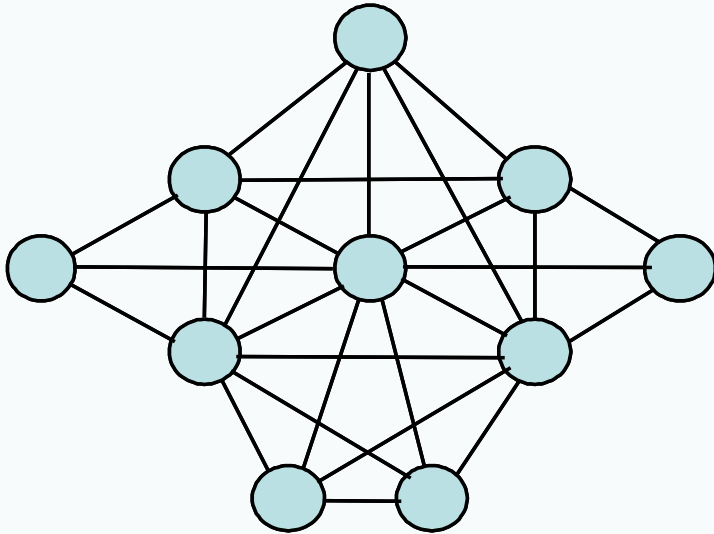
$$\text{Sum} = 5$$

Average shortest path length (λ) for node A = $5/3 = 1.67$

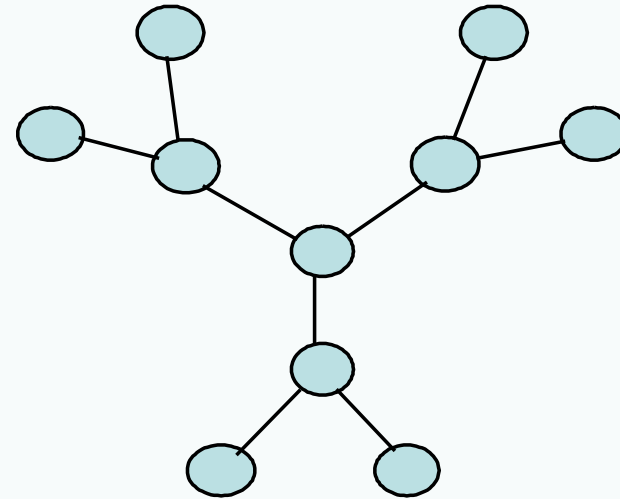
Characteristic path length for network (median λ) = median $\{1, 1.33, 1.33, 1.67\} = 1.33$

Diameter (maximum path length) = 2

Clustering coefficient



Strong local clustering





Weak local clustering

Components of hypothetical graphs with strong and weak local clustering

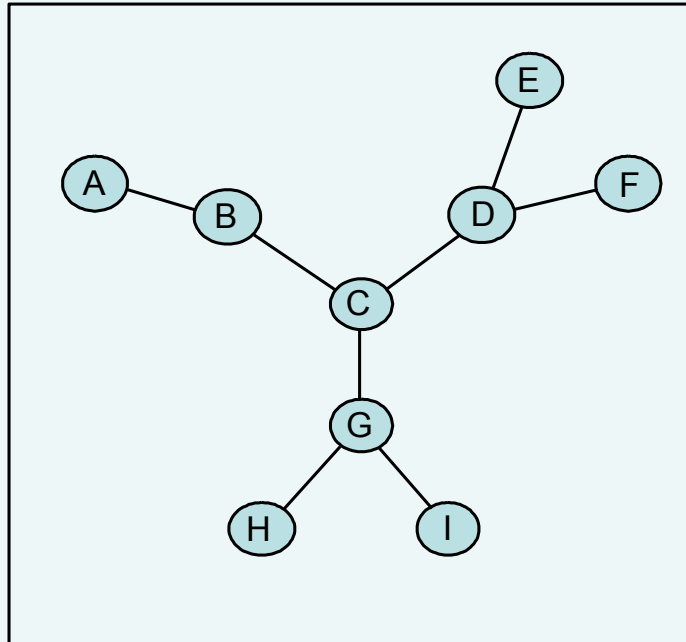
Small-world networks

- Short average path between nodes
- Strong neighborhood clustering

Properties common to many real-world networks

- Short average path length
 - Strong local clustering
- 
- Small-world**
- Power-law distribution in links for each node
- 
- Scale-free**

Average node degree



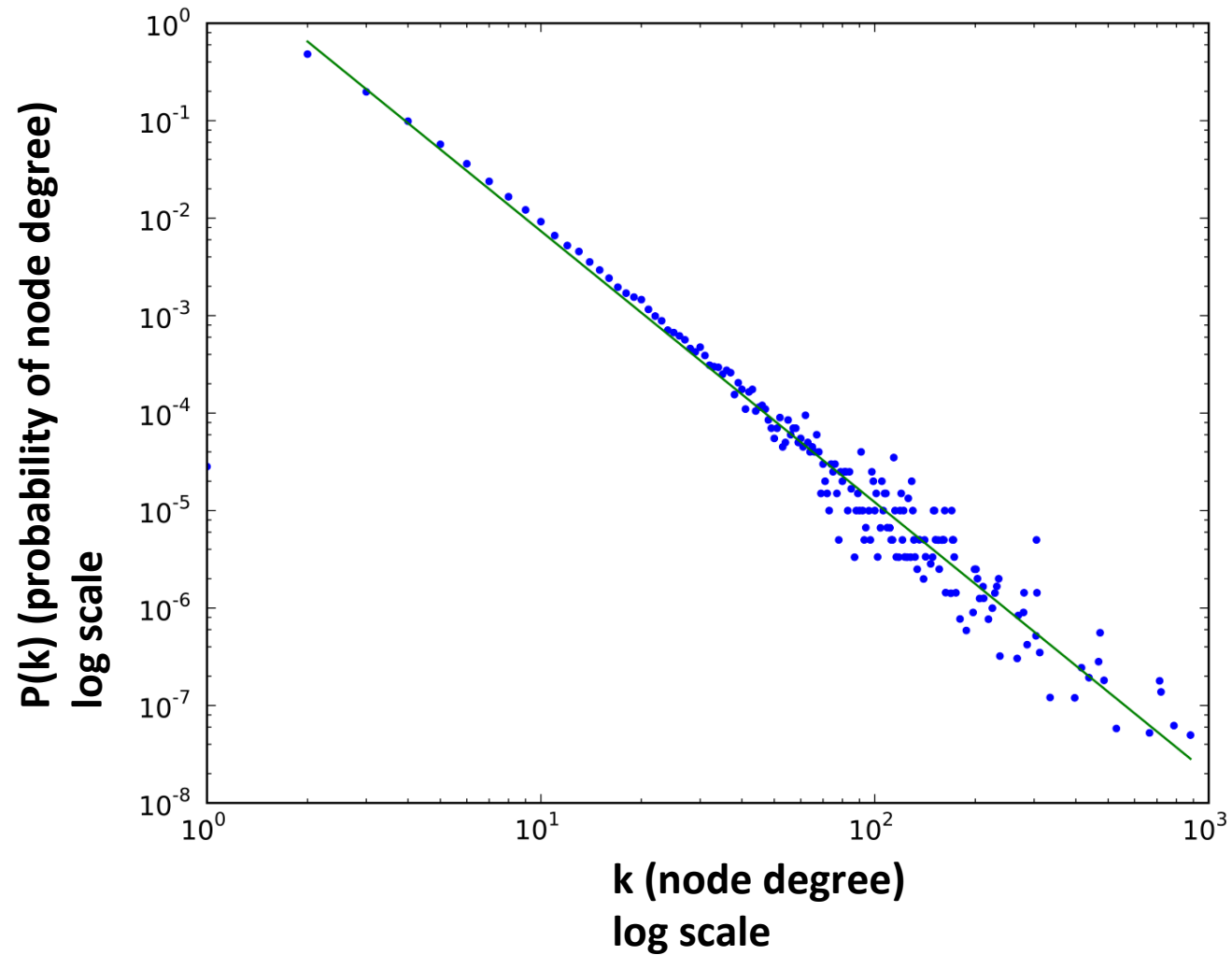
Node degrees

A = 1	D = 3	G = 3
B = 2	E = 1	H = 1
C = 3	F = 1	I = 1

$$\frac{8}{9} * 2 = 1.78$$

The degree of Node B is 2 and the degree of Node C is 3. The average node degree for the entire graph is 1.78.

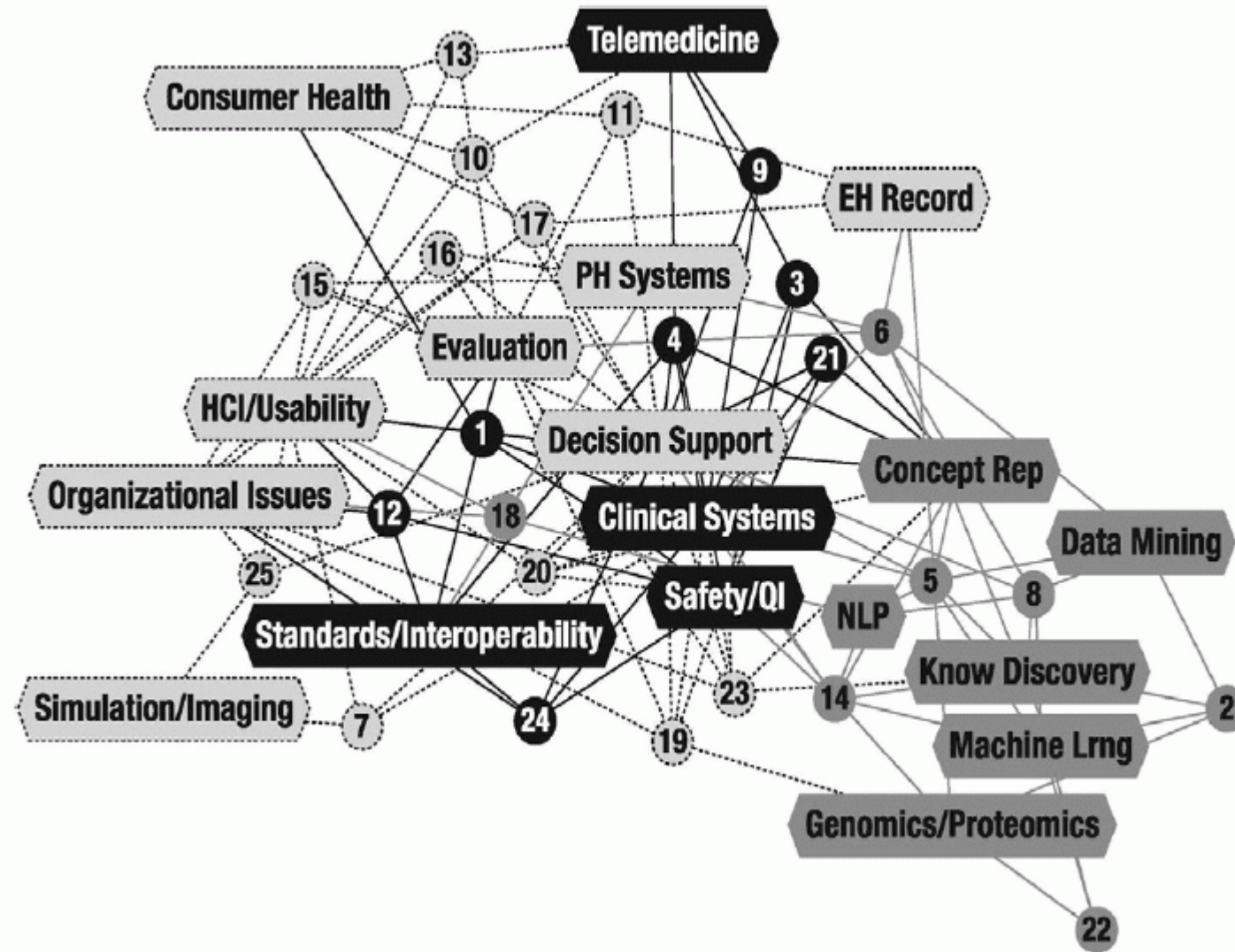
Power law distribution



Node degree distribution of scale-free network

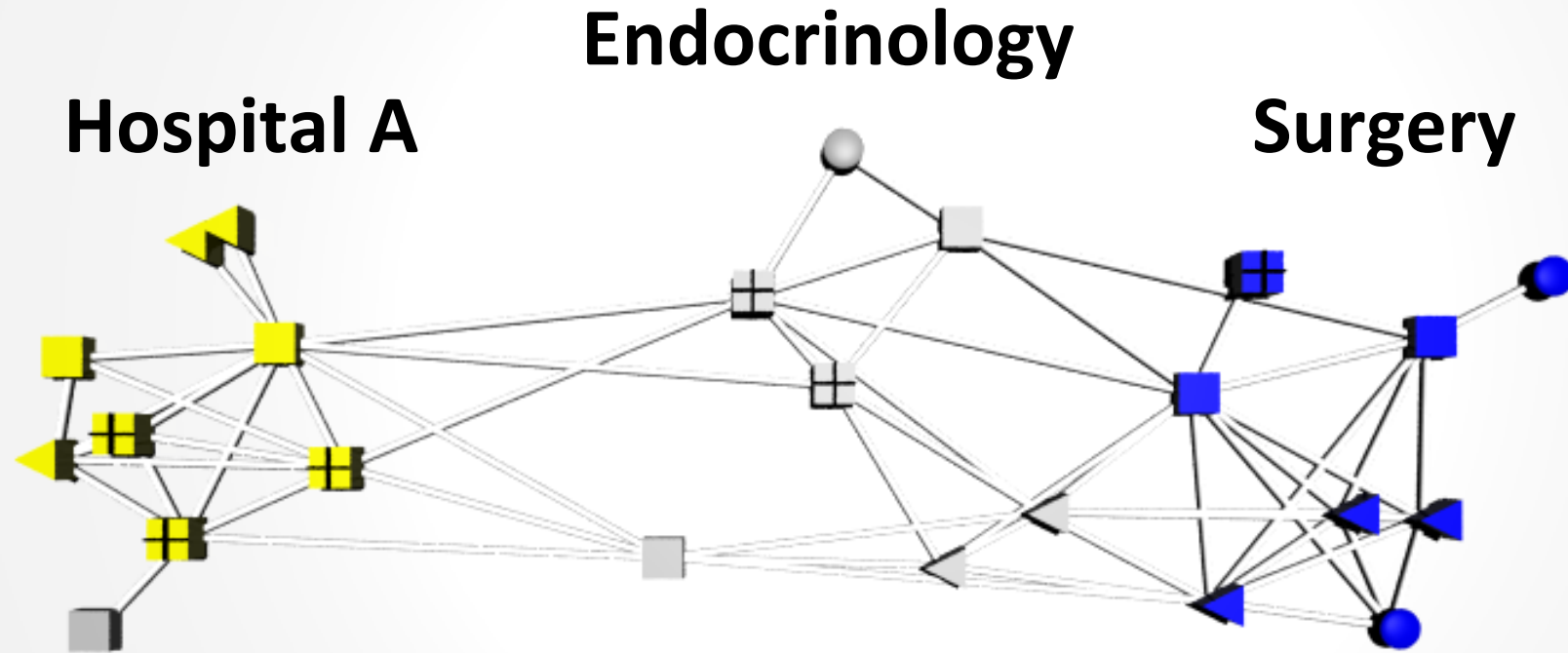


Image adapted from: Gomez SM, Lo SH, Rzhetsky A. Probabilistic Prediction of Unknown Metabolic and Signal-Transduction Networks. *Genetics*, Vol. 159, 1291-1298, 2001.

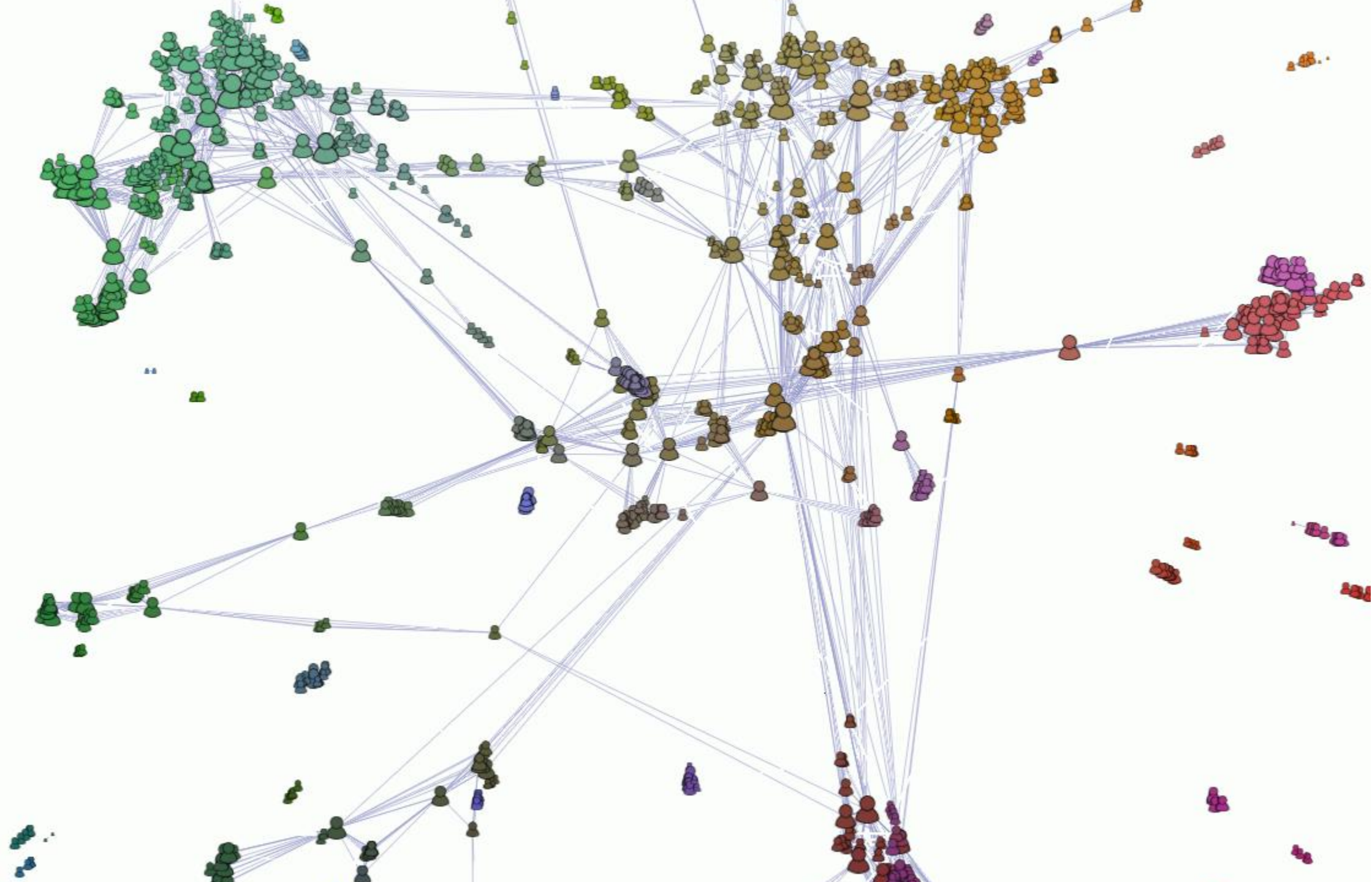


Merrill, J., & Hripcsak, G. (2008). Using social network analysis within a department of biomedical informatics to induce a discussion of academic communities of practice. *Journal of the American Medical Informatics Association*, 15(6), 780-782.

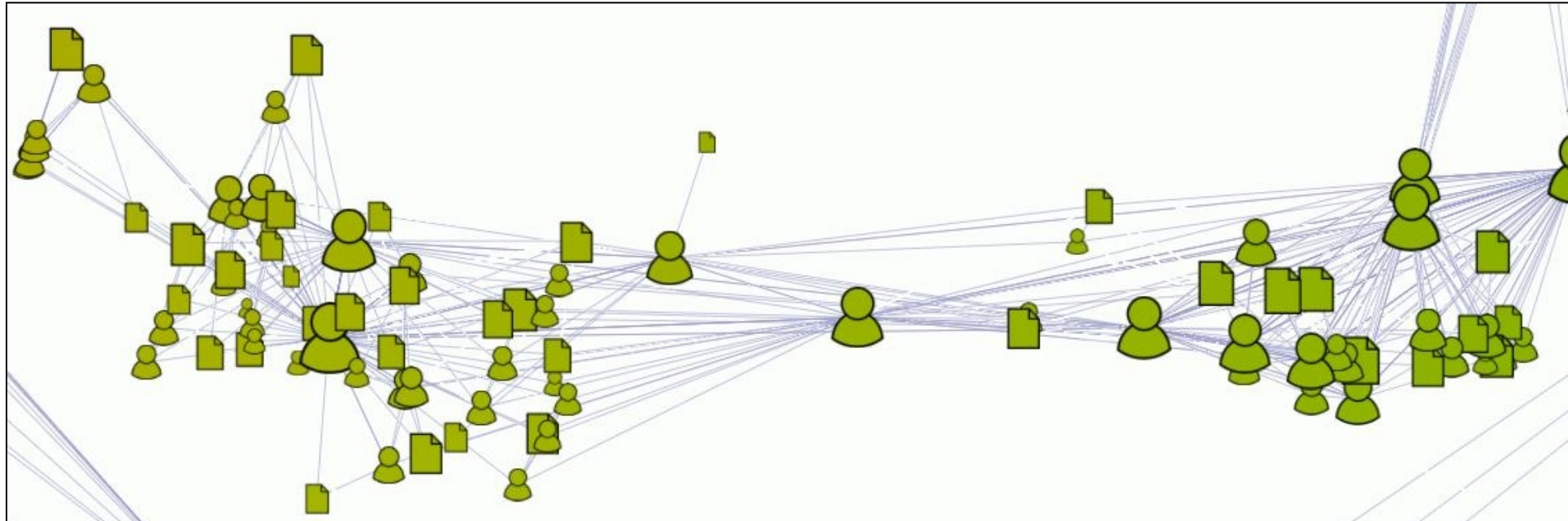
Obesity Research: Subgroups



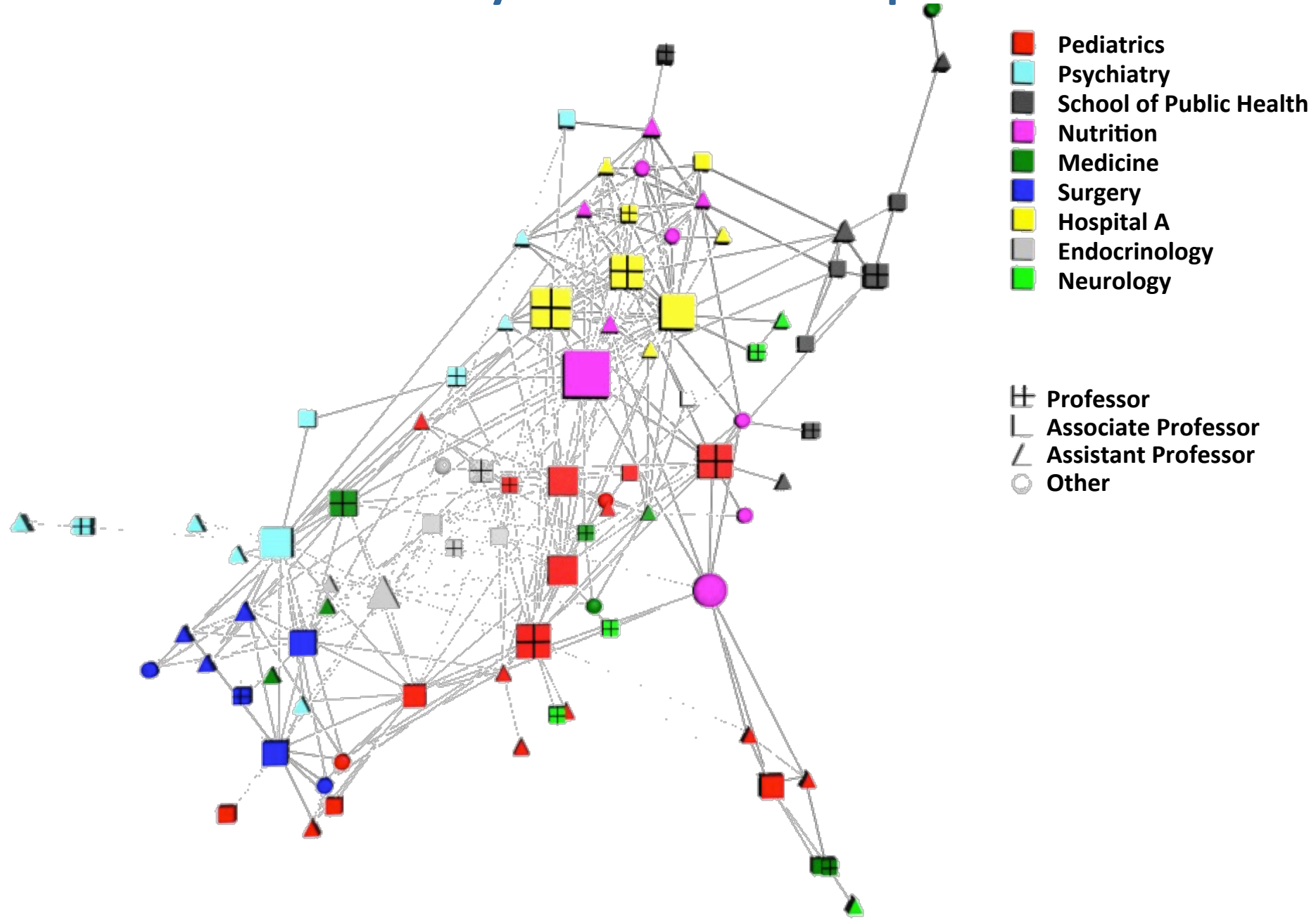
- ⊕ Professor
- Associate Professor
- △ Assistant Professor
- Other



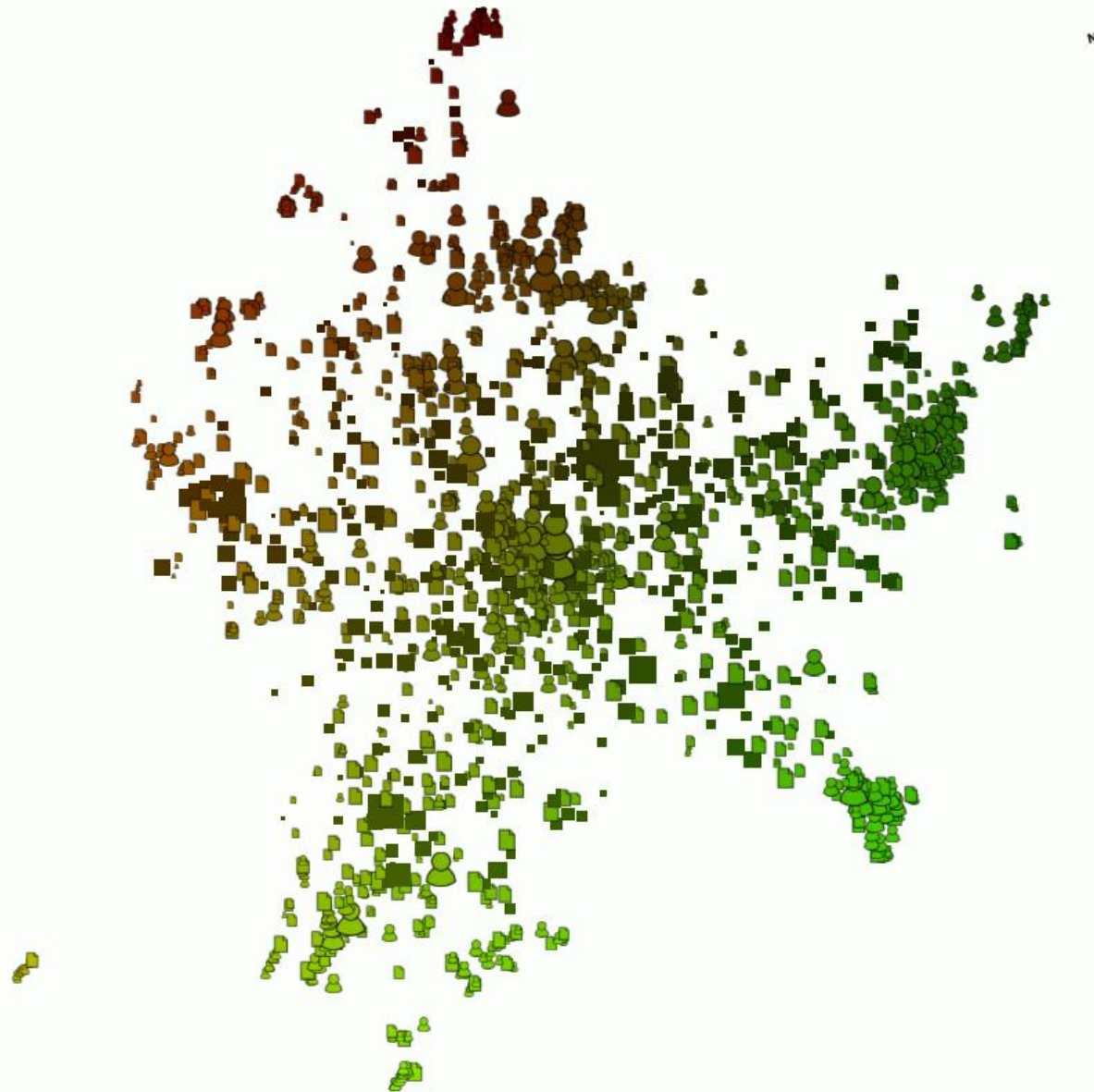
Bridges/brokers



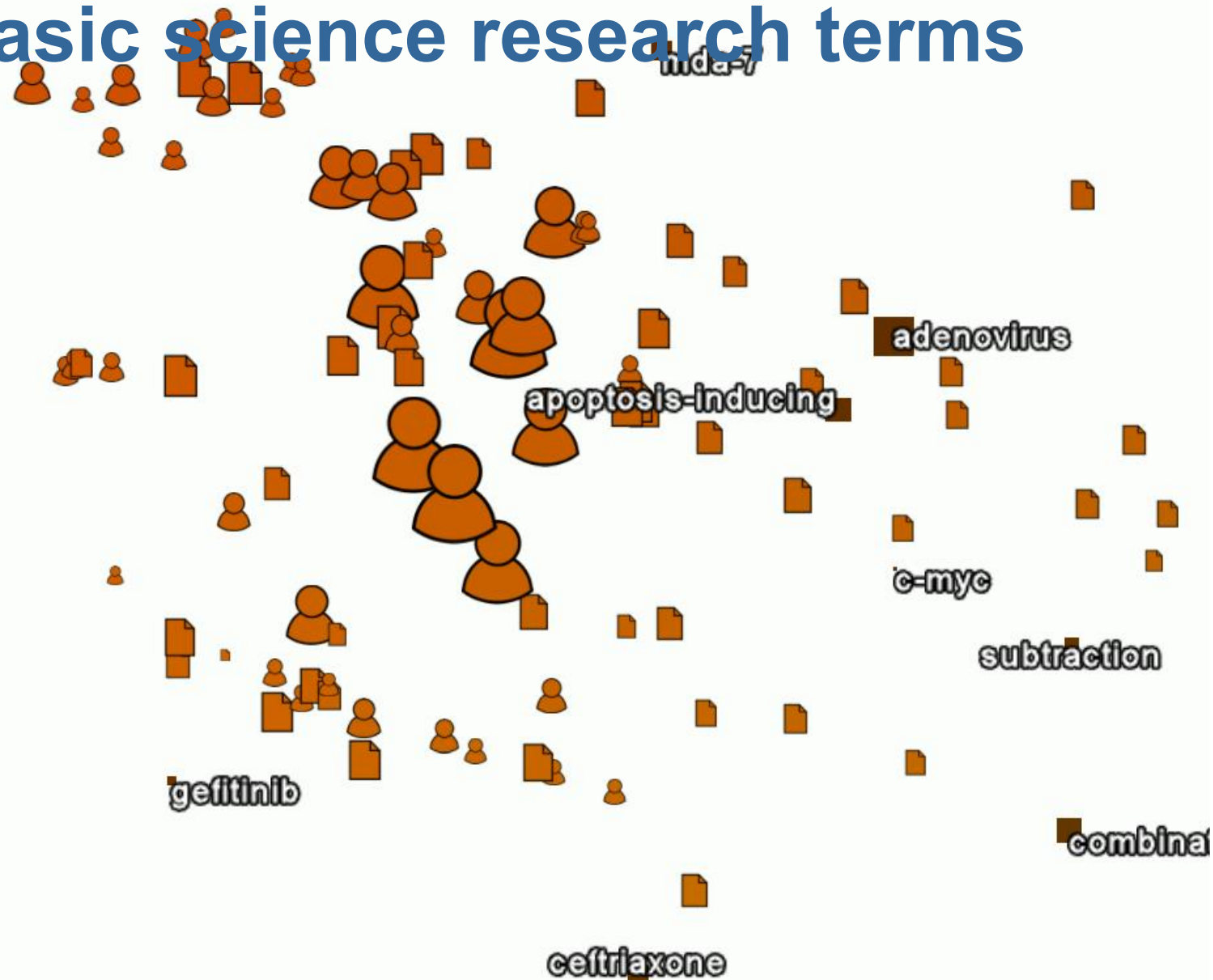
Obesity Research: Self report



urology AND "columbia presbyterian" [AD] AND
2004:2009 [DP]



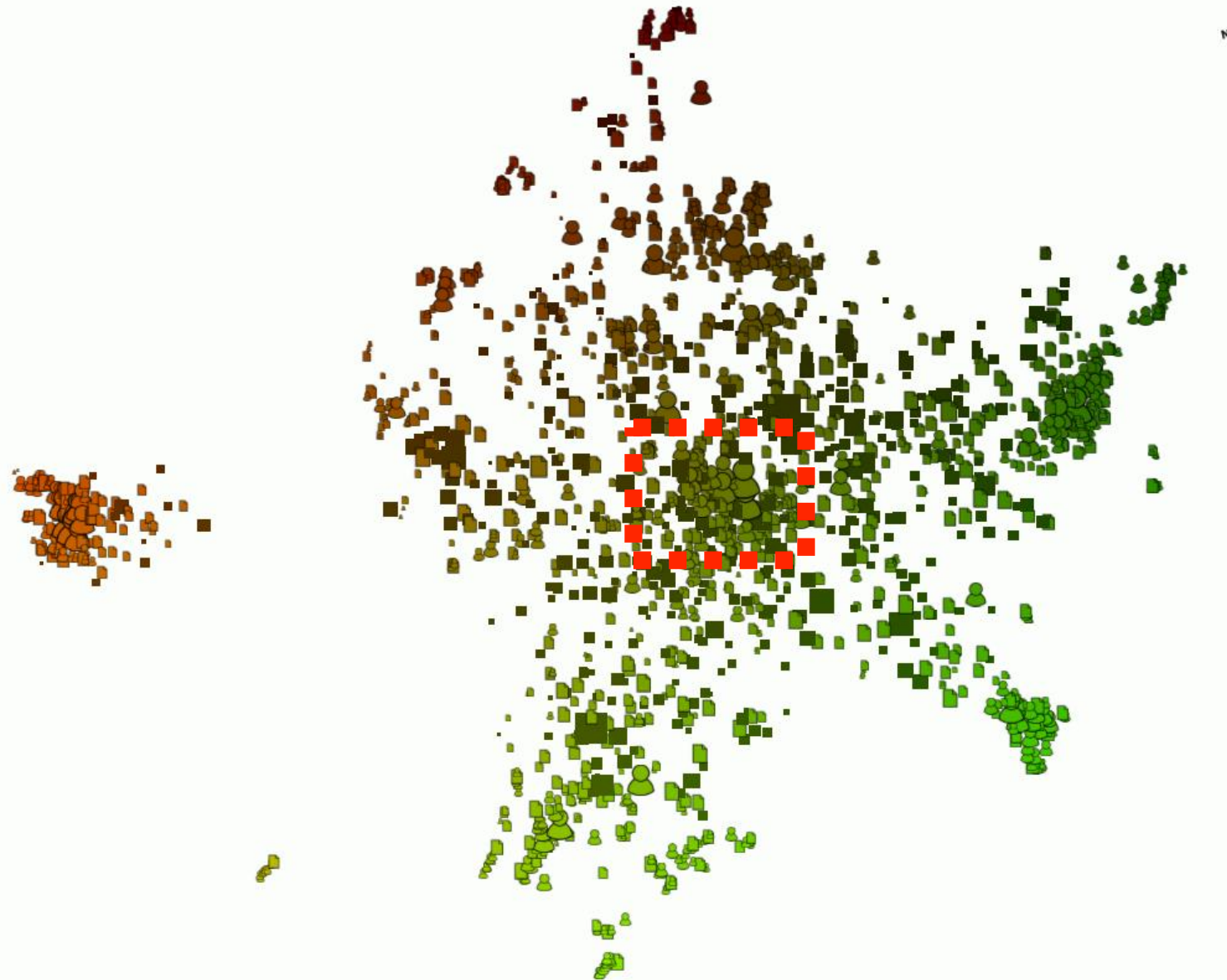
Basic science research terms



Data SIO, NOAA, U.S. Navy, NGA, GEBCO

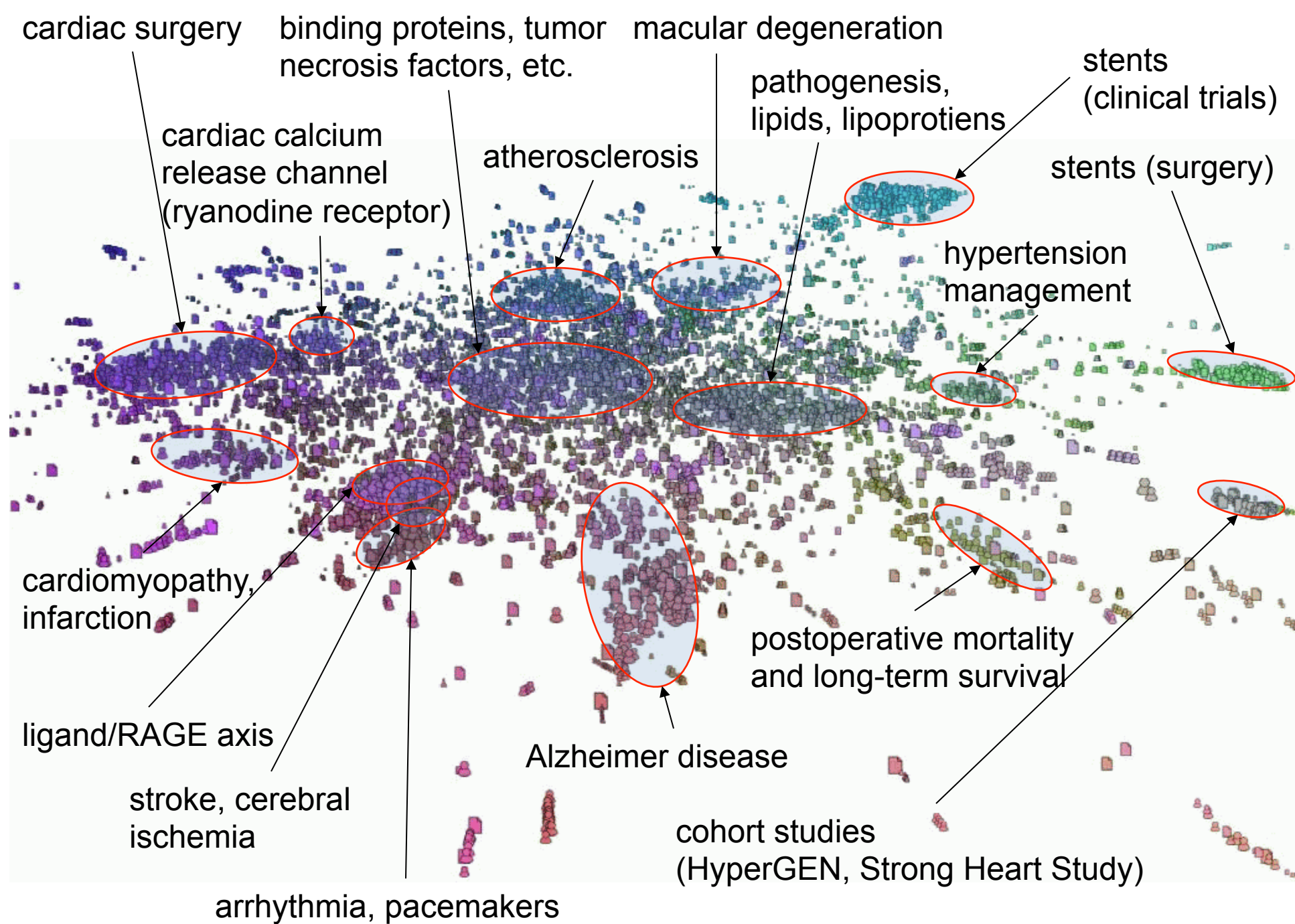
Google

urology AND "columbia presbyterian" [AD] AND
2004:2009 [DP]

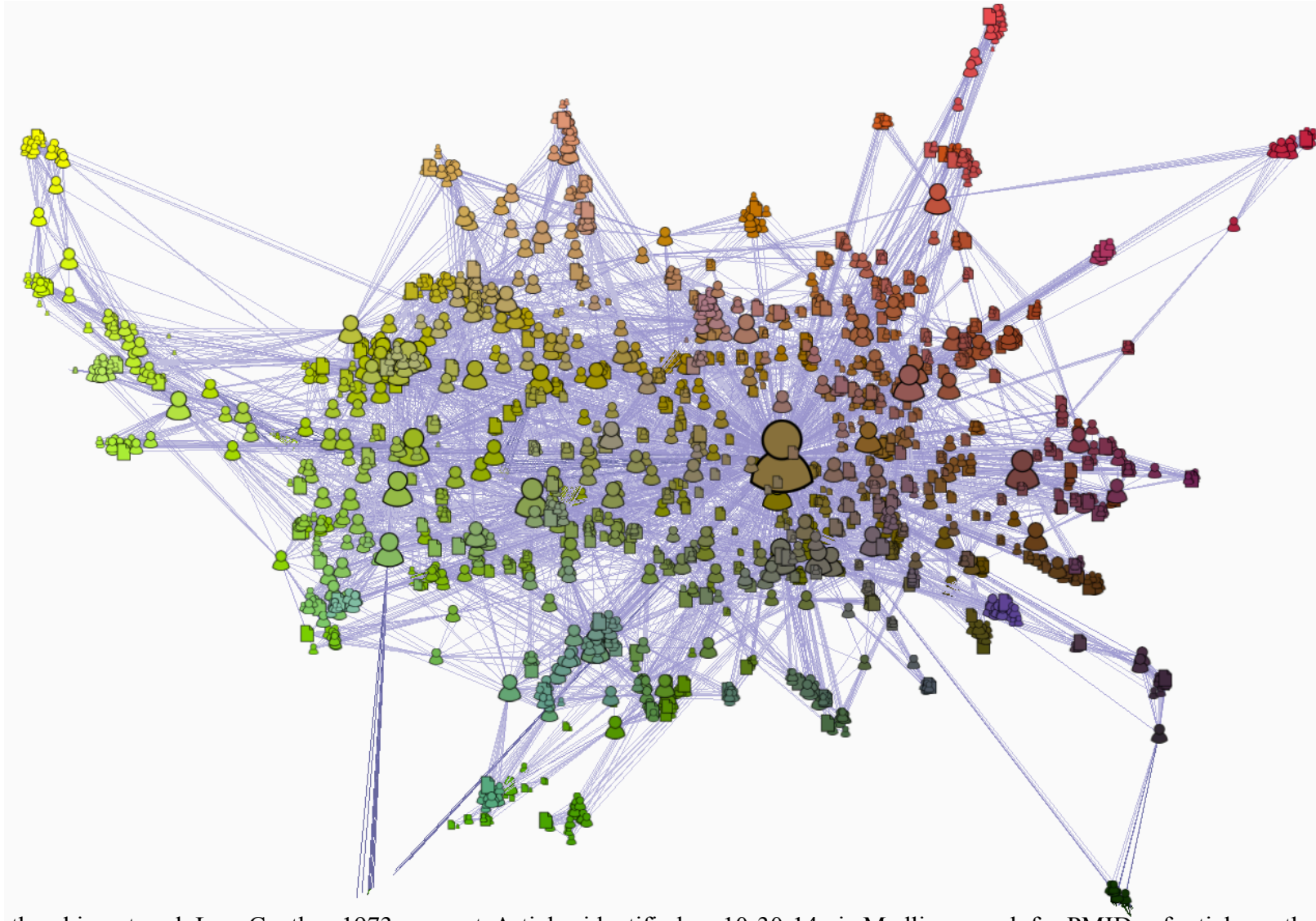


Clinical research terms





Co-Authorship Network of papers by Lew Cantley, 1973–present



Co-Authorship network Lew Cantley, 1973–present. Articles identified on 10-30-14 via Medline search for PMIDs of articles authored by Dr. Cantley in Weill Cornell's VIVO research networking system. Network includes authors and articles. Authors are linked to their co-authors and to papers. Node size reflects the number of links. Network layout is determined by a force-directed placement algorithm where all nodes repel one another and linked nodes are drawn closer together. Nearby nodes are assigned similar but not identical colors.